POWER MANAGEMENT OF INTERACTIVE WORKLOADS DRIVEN BY DIRECT AND INDIRECT USER FEEDBACK

TECHNICAL FIELD

[0001] This disclosure relates to the field of power management and, in particular, to power management in a computing system.

BACKGROUND

[0002] Many modern computing systems include power management functionality for reducing the overall amount of power consumed by the computing system. Power management may be implemented using software or hardware in the computing system capable of placing the computing system in different power states. For example, a power management scheme may cause the computing system to operate in the power state having the lowest power demand to conserve energy.

[0003] When executing a workload, a computing system may characterize the workload beforehand and adjust the system to effect a desired average response time. Other solutions may adjust the system based on ancillary metrics such as central processing unit (CPU) utilization, or end-to-end response; however, such metrics still may not accurately reflect a user's satisfaction with the response time.

[0004] In some computing platforms, users may be charged based on utilization time. This approach encourages users to prioritize performance when scheduling a job, since a faster completion time results in a lower cost to the user. However, users should have incentives for accepting a longer completion time in exchange for reduced power consumption.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The present disclosure is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings.

[0006] FIG. **1** illustrates a computing system according to an embodiment.

[0007] FIG. **2** is a block diagram illustrating functional components of a computing system, according to an embodiment.

[0008] FIG. **3** is a flow diagram illustrating a power management process, according to an embodiment.

DETAILED DESCRIPTION

[0009] The following description sets forth numerous specific details such as examples of specific systems, components, methods, and so forth, in order to provide a good understanding of the embodiments. It will be apparent to one skilled in the art, however, that at least some embodiments may be practiced without these specific details. In other instances, well-known components or methods are not described in detail or are presented in a simple block diagram format in order to avoid unnecessarily obscuring the embodiments. Thus, the specific details set forth are merely exemplary. Particular implementations may vary from these exemplary details and still be contemplated to be within the spirit and scope of the embodiments.

[0010] In one embodiment, a computing system implements a power management scheme that changes the power state of the computing system for execution of a task based on user inputs received during or prior to execution of the task. To execute a task, the user submits an input to the computing system requesting execution of the task. While the task is being executed, the user may submit additional inputs that cause the computing system to increase or decrease the power consumption for executing the task. In one embodiment, the computing system responds to the additional user inputs by switching the power state for executing the task. In one embodiment, the computing system is configured to switch the power state of processes that are related to the task, while leaving the power state of unrelated processes unchanged.

[0011] The additional inputs provided by the user are inputs that indicate the user's satisfaction with the response time for the task being executed; thus, this approach allows the computing system to dynamically balance power consumption and performance according to the user's satisfaction, which can be explicitly indicated or can be inferred based on the user's interaction with the system. The computing system is further configured to store the modified power state that is associated with the task in memory so that modified power state can be used for execution of the same task in the future.

[0012] In one embodiment, the stored power state defines one or more parameters for operating the computing system. These parameters may represent electrical operating characteristics for the computing system or for a processing unit in the computing system. For example, one type of processing unit that can be used in the computing system is a processor that is capable of operating at multiple voltage supply levels and multiple clock frequencies. Thus, each power state in such a computing system is associated with a particular combination of a voltage supply level and a clock frequency for the processor. In one embodiment, this technique for managing power consumption may be implemented in mobile devices (e.g., phones, tablets, laptops, etc.) which dynamically manage energy consumption while interacting with the user, as well as in the field of interactive analytics (which could perform data mining, or tasks such as speech recognition) to address and respond to user input.

[0013] In an embodiment of a computing system on which users can purchase computing time to perform requested tasks (e.g., a computer cluster), an initial user input requests execution of the task, then the computing system modifies the power state for executing the task based on a subsequent user input. Instead of merely estimating the completion time and cost for the task based on the maximum performance of the computing system or based on a performance level indicated by the user, the computing system may estimate completion times for execution of the task using one or more lower power consumption states. The computing system may then present these options to the user to allow the user to accept executing the task using a lower level of power consumption, resulting in a longer completion time for the task but decreased cost to the user. This approach incentivizes users to consider the power constraints of the computing system, when such users might otherwise overestimate their performance requirements or prioritize performance over power consumption.

[0014] FIG. **1** illustrates an embodiment of a computing system **100** which may implement a power management scheme that changes the power state of the computing system **100** based on user inputs as described above. In general, the computing system **100** may be embodied as any